DISPLAY DESIGN: A HUMAN FACTOR OF SPACEFLIGHT

Instructional Objectives

Students will

- construct null and alternative hypotheses to analyze the response times for left-aligned vs. right-aligned labels;
- choose an appropriate hypothesis test;
- check assumptions necessary to conduct the hypothesis test;
- perform the hypothesis test; and
- draw the correct conclusion based on the results of the test.

Degree of Difficulty

For the average student in AP Statistics, this problem is moderately difficult.

Class Time Required

This problem requires 50–70 minutes.

- Introduction: 5–10 minutes
  - Read and discuss the background section with the class before students work on the problem.
- Student Work Time: 35–45 minutes
- Post Discussion: 10–15 minutes

Background

This activity is part of a series of activities that applies Math and Science @ Work in NASA's research facilities.

The Habitability and Environmental Factors Division at NASA Johnson Space Center, located in Houston, Texas, is responsible for providing a safe and productive environment for humans in a spacecraft or habitat. The scientists, engineers, and other professionals who work in this division oversee the research and technology development that enables humans to safely and effectively live and work in space. Human physical parameters and performance capabilities as well as limitations are defined, documented, and applied to the design and operation of vehicles, habitats, and equipment.

This division is comprised of several fully-equipped laboratories and facilities, each with trained discipline specialists. These experts collaborate

Grade Level
11–12

Key Topic
Hypothesis Tests

Degree of Difficulty
Moderate

Teacher Prep Time
10 minutes

Class Time Required
50–70 minutes

Technology
- TI-Nspire™ Learning Handhelds
- *Display Design* TI-Nspire document

AP Course Topics
Exploring Data:
- Constructing and interpreting graphical displays of distributions of univariate data

Statistical Inference:
- Tests of significance

NCTM Standards
Data Analysis and Probability

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with universities, military institutions, industry, and other NASA centers to explore solutions to many complex issues involved with human space flight.

Figure 1: Eye tracking study for medical pack design

Figure 2: Crew restraint test on a reduced gravity flight

One of these facilities is the Usability Testing and Analysis Facility (UTAF). The UTAF provides human factors analysis, design evaluation, and research related to crew interfaces for work areas and equipment, such as computer displays, controls, and workstation systems. Software, procedures, and other mission-related products are also evaluated and developed. Data is measured about the users and their environment as well as the effectiveness with which they complete tasks.

The UTAF maintains a staff experienced in the rigors of researching and evaluating both cognitive human factors (human mental processes such as judgment and decision making) and ergonomic factors (the minimization of physical effort and discomfort through proper design). Some of its projects include long-duration mission habitability, microgravity workstations, crew restraints, medical training, and display issues, such as the readability of labels.

AP Course Topics

Exploring Data: Describing patterns and departures from patterns

- Constructing and interpreting graphical displays of distributions of univariate data (dot plot, stem plot, histogram, cumulative frequency plot)
  - Outliers and other unusual features

Statistical Inference: Estimating population parameters and testing hypotheses

- Tests of significance
  - Logic of significance testing, null and alternative hypothesis; p-values; one- and two-sided tests

NCTM Standards

Data Analysis and Probability

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Select and use appropriate statistical methods to analyze data
- Develop and evaluate inferences and predictions that are based on data

Problem and Solution Key (One Approach)

Students are given the following problem information within the TI-Nspire document, DisplayDesign.tns, which should be distributed to their TI-Nspire handhelds.

When astronauts view displays with multiple labels, they must quickly identify certain labels (words or values) from the displays. Does the alignment of the labels on displays affect the speed with which astronauts can accomplish this task? To answer this question, the Usability Testing and Analysis Facility (UTAF) conducted an experiment to compare response times for right-aligned versus left-aligned labels.

method	**up**
sys	**35**
data	**31**
period	**down**

Figure 3: Right-aligned 4-label display

method	**up**
sys	**35**
data	**31**
period	**down**

Figure 4: Left-aligned 4-label display

On each trial in the experiment, a target label (such as “method” in Figure 3) was presented to the subjects. After the subjects clicked on the target label, a screen appeared showing a display of 4 or 16 labels with corresponding values. The subjects clicked the value from the second display that corresponded to the target label on the first display. If the subjects had “method" as the target label on the first display, they would need to click the value "up" on the second display, since that is the value associated with the target label (see Figures 3 and 4). All subjects completed trials with both alignment types and display sizes. The order of the alignment and displays sizes was counterbalanced across subjects.

Each trial began when the subjects clicked on the target label on the first screen and ended when they clicked on the value corresponding to the target label on the second screen. The elapsed time between the first and the second click was recorded as response time.

Table 1: Response times (milliseconds) for left-aligned and right-aligned labels using 16-label displays

Subject ID number	Left-aligned 16-label displays	Right-aligned 16-label displays
1	2603	1938
2	2641	2976
3	2410	2492
4	2249	3103
5	2522	2887
6	1753	2475
7	2098	2884
8	1648	2820
9	2203	2224
10	3014	2749
11	2989	3357
12	2498	2260
13	1940	3074
14	2045	2137
15	1962	2130
16	2529	3451

Table 2: Response times (milliseconds) for left-aligned and right-aligned labels using 4-label displays

Subject ID number	Left-aligned 4-label displays	Right-aligned 4-label displays
1	1286	1364
2	1259	1391
3	1211	1283
4	1161	1245
5	1333	1222
6	1288	1251
7	1444	1382
8	1475	1364
9	1104	1102
10	1436	1462
11	2429	2252
12	1460	1224
13	1166	1225
14	1181	1219
15	1102	1101
16	1859	2073

A. Table 1 (TI-Nspire page 1.7) shows matching response times in milliseconds for 16 subjects for the 16-label displays. Perform an appropriate test to determine whether there is a difference in response times for left-aligned vs. right-aligned labels. Add the appropriate pages (data and statistics, calculator, and notes) to the TI-Nspire document in order to give a complete answer.

To add pages to the TI-Nspire document, press **ctrl** and **doc,** then select the type of page.

Component 1: State a correct pair of hypotheses.

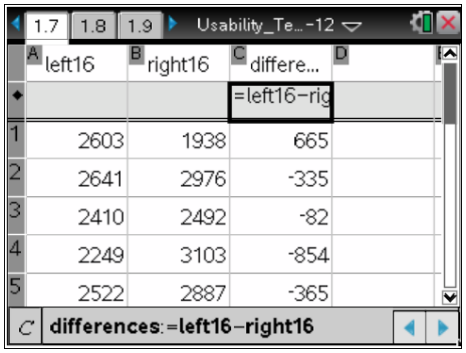
H_0: $\mu_0 = 0$ (The mean difference between left-aligned and right-aligned response times is 0.)

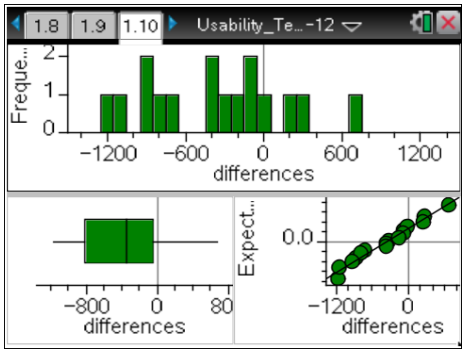
H_a: $\mu_0 \neq 0$ (The mean difference between left-aligned and right-aligned response times is not 0.)

Component 2: Identify a correct test (by name or formula) and check the conditions.

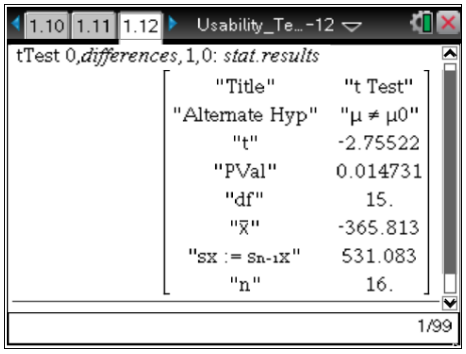
Use a matched pairs t-test.

Check the assumption that the distribution of differences is normal. Since the graphs of the differences show no outliers or extreme skewness and the normal probability plot is linear, it appears reasonable to proceed with a t-test.





Component 3: Perform correct mechanics, which includes the value of the test statistic and p-value (or rejection region).



Component 4: Draw an appropriate conclusion in context and with linkage to the p-value (or rejection region).

Since the p-value (0.015) is less than 0.05, we reject H_0 and conclude that there is a difference in left-aligned and right-aligned response times.

Since $x = -365$ ms, we also conclude left-aligned response times are slightly shorter than right-aligned response times.

B. The previous question involved displays with 16 labels per display. Table 2 (TI-Nspire page 2.2) shows results from a similar experiment that used 4 labels per display. Perform an appropriate test to determine whether there is a difference in response times of left-aligned and right-aligned labels for the 4-label displays. Add appropriate pages (data and statistics, calculator, and notes) to the TI-Nspire document in order to give a complete answer.

Component 1: State a correct pair of hypotheses.

H_0: $\mu_0 = 0$ (The mean difference between left-aligned and right-aligned response times is 0.)

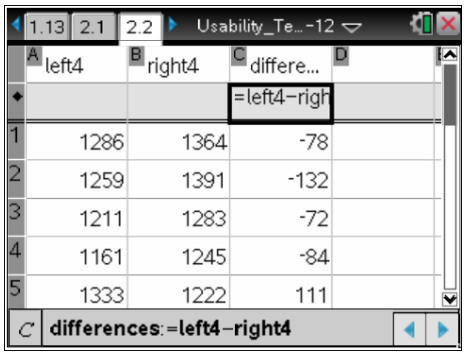
H_a: $\mu_0 \neq 0$ (The mean difference between left-aligned and right-aligned response times is not 0.)

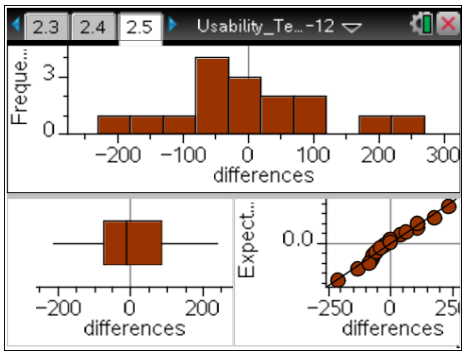
Component 2: Identify a correct test (by name or formula) and check the conditions.

Use a matched pairs t-test.

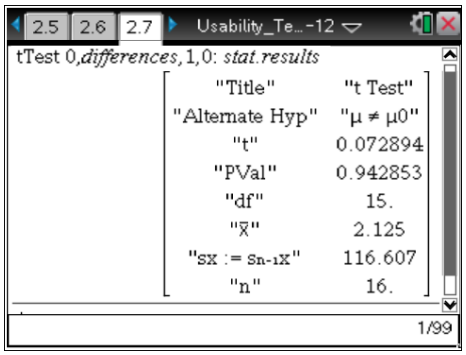
Check the assumption that the distribution of differences is normal. Since the graphs of the differences show no outliers or extreme skewness and the normal probability plot is linear, it

appears reasonable to proceed with a t-test.





Component 3: Perform correct mechanics, which includes the value of the test statistic and p-value (or rejection region).



Component 4: Draw an appropriate conclusion in context and with linkage to the p-value (or rejection region).

Since the p-value (0.943) is greater than 0.05, we cannot reject H_0. We conclude that there is no difference in left-aligned and right-aligned response times when the displays only contain 4 labels.

Scoring Guide

Parts A and B are scored as Essentially Correct (E), Partially Correct (P), or Incorrect (I).

Question	Score	Description
A	*Essentially Correct (E)*	All four components are correct.
	Partially Correct (P)	Two or three components are correct.
	Incorrect (I)	At most, one component is correct.
B	*Essentially Correct (E)*	All four components are correct.
	Partially Correct (P)	Two or three components are correct.
	Incorrect (I)	At most, one component is correct.

Point Distribution

Suggested 4 points total to be given as follows:

4 pts	**Complete Response**	Both parts A and B are essentially correct.
3 pts	**Substantial Response**	One part is essentially correct and one part is partially correct.
2 pts	**Developing Response**	Two parts are partially correct. *OR* One part is essentially correct and one part is incorrect.
1 pt	**Minimal Response**	One part is partially correct and one part is incorrect.

Contributors

This problem was developed by the Human Research Program Education and Outreach (HRPEO) team with the help of NASA subject matter experts and high school AP Statistics instructors.

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